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Whole grain dietary recommendations – the need for a unified global approach

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Abstract

Increased whole grain (WG) consumption reduces the risk of CVD, Type 2 Diabetes and some cancers, is related to reduced body weight and weight-gain and to improved intestinal health. Definitions of 'WG' and 'WG food' are proposed and used in some countries but these are not consistent. Many countries promote WG consumption but the emphasis given and the messages used vary. We surveyed dietary recommendations of 53 countries for mentions of WG to assess the extent, rationale and diversity in emphasis and wording of any recommendations. If present, recommendations were classified as either 'Primary', where the recommendation was specific for WG or 'Secondary', where recommendations were made in order to achieve another (primary) target, most often dietary fibre intake. 127 organisations were screened, including government, non-governmental organisations, charities and professional bodies, the WHO and EFSA, of which 49 including WHO provide a WG intake recommendation. Recommendations ranged from 'specific' with specified target amounts (e.g. xg WG/day); 'semi-quantitative' where intake was linked to intake of cereal/carbohydrate foods with proportions of WG suggested (e.g. x servings of cereals of which y servings should be WG); to 'non-specific' based on 'eating more' WG or 'choosing WG where possible'. This lack of a harmonized message may result in confusion for the consumer, lessen the impact of public health messages and pose barriers to trade for the food industry. A science-based consensus or expert opinion on WG recommendations is needed, with a global reach to guide public health decision making and increase WG consumption globally.

Introduction

Cereals are the dominant source of carbohydrate in the diet worldwide and are significant contributors to protein intake in some countries where alternative crops and animal sources are not viable, or are not consumed on religious grounds. Global cereal production approached 2,525 million tonnes in 2014, of which wheat (28%) and rice (20%) accounted for approximately half of total production [(1)]. Cereals require processing before consumption, either by cooking intact kernels or by milling and fractionation to produce flours. Since the development of the roller milling process the tendency has been for the majority of cereals to be processed into (refined) flours by removing the outer layers of the kernel and the germ. As a result, consumption of whole grains and/or wholemeal flours has declined in many industrialised countries to the detriment of a more healthy diet pattern. Recent evidence points to the benefits of consuming whole grains which are associated with lowered risk of several non-communicable diseases including type 2 diabetes, cardiovascular diseases and some cancers. However, in many countries whole grain intake is low despite efforts to promote their consumption by industry and government agencies. Reasons for low intake are complex but may include low consumer preference, lack of available products, cost differential between whole-grain and refined-grain products, and lack of awareness of whole grains. Increasing intake of whole grains requires a concerted effort from health agencies and industry to standardise definitions of whole grains and whole-grain foods and to promote their consumption more effectively, including through national health initiatives.

Composition of Cereals

Cereals are plants of the *Gramineae* family of grasses and their seeds (grains) are characterised by their similarity in anatomical structure (see Figure 1 for diagram of a wheat kernel), although not their overall chemical composition. Some so-called pseudo cereals are also included in the grain category because their structure is similar to true grains. Cereal grains have three principle anatomical components each related to their function within the seed, and each with unique composition which affects the overall nutritional value of the different grain species. The bran is a multi-layered structure, the natural, tough protection of the seed beneath. There are several distinct layers including the pericarp and aleurone

layers each further sub-divided. These layers can be removed with great precision in modern milling methods; removal of each layer affects the nutrient profile of the fractions, especially dietary fibre(s), some vitamins and minerals and phytochemicals. The bran layers are also a principle source of phytochemicals and contribute to the antioxidant potential of grain. The biggest part of the grain is the endosperm which comprises from about 60% up to almost 85% of the cereal grain dry weight, depending on species. Nutritionally the endosperm is mainly carbohydrate in the form of starches with smaller amounts of oligosaccharides such as fructans. Protein is found in the extracellular matrix, and there are some B vitamins in particular pantothenic acid and riboflavin. The germ is the smallest fraction of the grain at about 2.5% of the grain weight. The germ is the growing part of the seed and it has a high lipid and protein content, with minerals such as potassium, calcium, magnesium and zinc, and both water- and fat-soluble vitamins including vitamin A, tocopherols and tocotrienols.

Definition of whole grain

Various definitions of whole grain have been suggested, largely based on a definition proposed by the AACC International; “whole grains consist of the intact, ground, cracked or flaked caryopsis (kernel) after the removal of inedible parts such as the hull and husk. The principal anatomical components - the starchy endosperm, germ and bran - are present in the same relative proportions as they exist in the intact kernel”. A similar definition is proposed by the European HEALTHGRAIN Forum for adoption in the EU [(2)]. Each definition recognises that in modern milling processes the anatomical components of the grain are fractionated during milling but can be re-combined to produce a wholemeal flour which contains all three components of the grain in the same relative proportions as the intact grain. No distinction is made between the nutritional value of such recombined flours compared with traditional stone-ground flours where the grains are crushed without separation of the component fractions. The HEALTHGRAIN definition also recognises that some parts of the grain, especially the outermost layers, are deliberately removed during processing to cleanse potentially contaminated parts of the husk and outer bran. The FDA has issued draft guidelines for the food industry for use in identifying whole grains and in the use of different labelling terms to provide factual information on their products [(3)].

Definition of whole-grain food

There has been little consensus on a definition of 'whole-grain foods' both in terms of that used in scientific publications or within the food industry. Accurate labelling of whole-grain foods is needed to ensure that the consumer can properly differentiate between foods made entirely with whole grains, those where the majority of grains are whole (whole grain rich), and foods which contain more refined grain than whole grain. The US FDA in its health claim definition has categorised a food product as being 'whole-grain' if it contains more than 51% wholegrain ingredients by weight/reference amount customarily consumed (RACC) [4; 5]. The same criterion was applied by the Joint Health Claims Initiative in the UK [6], but this is not a legal requirement. The Whole Grains Council provide a current list of definitions applied in different countries, including those used for their own Whole Grain Stamp [7] which demonstrates the wide variation in standards. A recent round table of experts has proposed that 8 g of whole grain/30 g serving (27 g/100 g), without a fibre requirement, be considered a minimum content of whole grains that is nutritionally meaningful and that a food providing at least 8 g of whole grains/30-g serving be defined as a whole-grain food [8]. Limitations in this proposed definition of a whole-grain food have been identified by the Whole Grains Council in its submission on whole grain label statements to the FDA [9]. Mostly these arise in foods which have a high moisture content (such as bread products, ready-cooked pasta/grains and mixed ready meals), and foods which have a naturally low grain content but the portion size is >30g. Refinement of the definition is therefore required so that naturally 'healthy' foods are not excluded from the category. The lack of clarity around a definition of what constitutes a whole-grain food confounds data analysis and comparison between studies. It is also not helpful for the food manufacturer or the consumer and gives rise to a number of different labelling approaches in ingredient lists and packaging stamps which makes identifying healthy whole-grain options difficult [10]. The effect of using different definitions for whole-grain foods, for example, is well illustrated from analysis of data from the National Diet and Nutrition Surveys in the UK where the effect of using different cut-off values for whole grain content was examined [11; 12]. Overall, in young people under 19 years of age, foods with ≥51% whole grain content contributed 72% (95% CI 70, 74) to whole grain intake. Foods with between 25 and 51% whole grain contributed 13% (95% CI 11, 15) to whole grain intake,

with the remainder contributed by those containing between 10% and 25% whole grain [11]. In the analysis of the secular trend in whole grain intake in adults Thane *et al*. [12] again showed that foods with <51% whole grain content are important contributors to whole grain intake, providing 18% of overall whole grain intake in the 1986-7 survey and 27% in 2000-1. If a cut-off point of 25% rather than 10% whole grain content was used whole grain intake would have been underestimated by 6% in 1986-7 and by 10% in 2000-1. Choosing an appropriate cut-off value also has important implications for public health and industry. There is an understandable concern that defining products with <25% whole grain as whole-grain foods may include foods with undesirable nutrient profiles which would be detrimental to population health. There are obvious consequences for recommendations for whole grain intake.

Whole grain intake levels

Consumption of whole grain varies greatly between countries and cultures, with some countries maintaining a more traditional dietary pattern in which wholegrain foods dominate compared with more recent processed refined grain alternatives. Determining whole grain intake in populations has been problematic for a number of reasons: (1) in many studies, whole grain intake was determined more than 25 years ago when the number of whole-grain foods available for purchase was much lower than currently; (2) the majority of data on whole grain intake has traditionally been derived from North American population-based studies which may not be nationally representative in which food intake is calculated from food frequency questionnaires (FFQ) mostly not originally designed for this purpose; (3) the number and descriptor of the foods included in FFQ is limited; (4) the percentage of whole grain content used to define the whole-grain foods included in analyses varies between 10 and 51%; (5) there is no standardisation of portion/serving sizes used when calculating intake, and (6) in many countries there is no standard list of the actual whole grain content of the majority of foods as this is not a standard component of food tables. Data on foods in the US are now publicly available through the US Department of Agriculture Food Patterns Equivalents Database [13] and recently the whole grain content of foods in Australia has been published [14]. No similar databases are currently available for European or Asian populations. On balance, it is likely that whole grain intake is probably higher than originally reported, and this needs to be reinvestigated.

Available studies, however, universally reveal low levels of consumption in North Americans and most Europeans (Table 1). Much of the data are quite old, and the availability and range of whole-grain foods in the marketplace has changed considerably in recent years. Overall, however, the results suggest that whole-grain intake has not changed much over time except where specific public health campaigns have taken place such as in Denmark (Mejborn *et al*., 2013). The majority of published data are reported at a population level i.e. they are median/mean values for the whole population including consumers and non-consumers in the calculations. Intake data from observational studies may be reported by quartiles or quintiles of intake adding to the complexity of comparison with population data. In some of the first results published less than 20% of the 38 740 postmenopausal women participating in the Iowa Women's Health Study consumed 3 or more servings of whole-grain foods per day [(15)]. Similar consumption levels were reported in another American cohort of 38-63 year old females in the Nurses' Health Study [(16)]. Analysing food consumption data from the Market Research Corporation of America, Albertson and Tobelmann [(17)] found that 90% of those under 19 years old and 73% of those aged over 19 years reported less than one whole grain eating occasion per day. In the UK, more recent data (but also more than 15 years old) from the National Diet and Nutrition Survey (NDNS) showed that median whole grain intake was less than 1 serving per day, over 97% of adults and young people under 18 years old did not achieve 48g/day and more than 30% of individuals consumed no whole grain at all [(11; 12)]. The most up to date data for the UK, from the first three years of the NDNS Rolling Programme for 2008/9-2010-11, show that although intake has increased slightly since 2001, intake remains low, and 20% of the population still consume no whole grains [(18)]. Similar low intake levels were found for those over 65 years of age by Lang *et al*. [(19)], and in older women from the Iowa Women's Health Study mean intake was again lower, ranging between 1.8 (SD 1.1) serves per week in the lowest quintile to 25.7 (SD 7.5) serves per week in the highest quintile.

Whole grain intake in Northern European countries is higher than in most other countries, particularly other European nations and the American continent. Whole-grain food and whole grain intake estimates across the Scandinavian countries have recently been reported by Kyro *et al*. [(20)]. The study population of 8702 adults was from the HELGA cohort study on 'Nordic health and whole grain food' randomly selected as a subset from the three

prospective Scandinavian cohort studies; The Norwegian Women and Cancer Cohort, The Northern Sweden Health and Disease Cohort and the Danish Diet Cancer and Health Cohort. Whole grain intake was determined from a comprehensive 24h dietary recall using EPIC-soft software which includes country-specific food and recipe lists with traditional foods and dishes [21]. Further Danish data from Egeberg *et al.* [22] based on the total weight of foods containing whole grains, show similar high intakes of whole-grain foods for adults at 140 (95% CI 48,279) and 119 (95% CI 40,237) g whole-grain foods/day for men and women, respectively. There is a dearth of published data on consumption of whole grains in the Asian region. Data from the National Nutrition Survey of Singapore in 2010 [23], and a recent study in Malaysian children and adolescents [24] suggest that whole grain intake in this region is low.

Whole grain health claims

The health benefits of whole grain were recognised by some National organisations through the development of health claims permitted for use on wholegrain foods. The first, established by the US FDA in 1999, was modified in 2003 and states ''Diets rich in whole grain foods and other plant foods, and low in saturated fat and cholesterol, may help reduce the risk of heart disease'' [5]; the claim is still in use. In Europe, similar claims previously in use in the UK and Sweden, are no longer allowed following the decision by the European Food Safety Authority (EFSA) not to approve a whole grain health claim on the grounds that whole grain was 'insufficiently characterized' [25]. A particular issue in this context is the use of the term 'whole grain' to encompass all the grains; applications for health claims were not specific to individual grains (i.e. wholegrain wheat or wholegrain rye). This is similar to the use of 'fruit and vegetables' where dietary recommendations are for the most part based on the whole food group with few countries specifying relative amounts of fruits and vegetables, and none specifying specific amounts of individual fruits or vegetables. In Southeast Asia, only Singapore permits the use of a health claim relating whole grains and reduction of risk of heart disease and some types of cancers [26].

Food-based dietary guidelines

Most countries have developed food-based dietary guidelines (FBDG) appropriate for their population, recognizing that these have become an accepted tool for promoting appropriate dietary patterns. These guidelines are often a set of positive messages that cover the whole range of food and nutrition issues, from importance of consuming a variety of foods to guidance on specific food groups, messages to encourage physical activities, consuming safe food and beverages and making effective use of nutrition information on food labels. The topics included in national FBDG and approaches to presentation of these messages differ widely across the countries.

Dietary recommendations in most countries are developed by expert panels and disseminated through national health agencies and can be based on nutrients and/or foods. EFSA have proposed a framework for the development of FBDG appropriate for whole grain based on the following principles [27]:

1. Identification of diet-health relationships
2. Identification of country specific diet-related health problems
3. Identification of nutrients of public health importance
4. Identification of foods relevant for FBDG
5. Identification of food consumption patterns
6. Testing and optimising FBDG
7. Graphical representations of FBDG
8. FBDG should focus on the diet-disease relationships of particular relevance to the specific population and should be developed using a multi-disciplinary approach.

FBDG should be policy recommendations based on the best available scientific evidence; the principles suggested by EFSA imply that they should be appropriate for the region or country for which they are intended and, importantly, they should be practical to implement. EFSA state that they should be consistent, easily understood and easily memorable.

Current whole grain dietary recommendations

Many dietary guidelines have recommendations for specific food items, for example cereal-based products, fruits and vegetables, milk and dairy products, legumes. Less frequently whole grains are included, but the extent to which they occur is unknown. Therefore, we

conducted a survey of current whole grain dietary recommendations, reviewing web sites and personal communication with national governmental and professional health agencies/organisations using a network of nutritionists available to us. Recommendations, if present, were initially classified into two categories (a) Primary, where the recommendation was specific for whole grain and (b) Secondary, where the recommendation was made in order to achieve another (primary) target, most often dietary fibre intake. The rationale behind any recommendations was noted where this information was provided. Fifty-three countries plus the WHO and EFSA were surveyed and results obtained from 127 separate organisations, including national competent authorities, non-governmental organisations (NGO), charities and professional bodies, the WHO and EFSA (Table 2). Recommendations were variable and inconsistent and fell into three categories as shown in Table 3; specific recommendations where a target daily amount was specified; semi-quantitative recommendations where a recommendation was based on servings of cereal foods with proportions of whole grain suggested; and non-specific recommendations based on 'eating more' or 'choosing' wholegrain options. Specific recommendations adopted by government agencies, including target intake amounts were found for only 2 countries (US and Denmark). For some countries different recommendations were found for NGOs, charities or professional bodies but not government; for example in Australia the Grains and Legumes Nutrition Council [28] suggests a whole grain daily target intake (DTI) of 48 g whole grain per day for adults and children nine years and older, but the Australian Government Department of Health and Ageing Dietary Guidelines for Australians has only a generic recommendation "eat plenty of cereals (including breads, rice, pasta and noodles), preferably wholegrain". This inconsistency in approach largely arises from the rationale given for the recommendations which are mostly associated with setting targets for dietary fibre intake and promoting whole grains as rich sources of dietary fibre, rather than being based on health benefits of consuming whole grains *per se*. Thus a gap exists between the scientific consensus that whole grains are beneficial to health, and public health policies designed to promote healthy eating. A full list of the available recommendations can be found in the Supplementary material.

Development of global whole grain recommendations

Grain foods are universally recognised by government health agencies as the cornerstone of dietary recommendations alongside other carbohydrate-rich sources, and are promoted as essential providers of dietary energy and other essential nutrients including dietary fibre. Thus they are often found in the base of food pyramids, or the largest segment of plate models used to illustrate food-based dietary recommendations to the general population. In these systems no distinction is made between cereal types and whole grains are not generally specified. The Harvard Healthy Eating Pyramid [29] suggests the consumption of wholegrain foods (at most meals) and the Iberoamerican Nutrition Foundation (FINUT) has recently proposed a three-dimensional food and lifestyle pyramid which has 'cereal and cereal products >50% wholegrain' as the second tier of the pyramid, also acknowledging the importance of this food category [30]. Food guides are broadly similar in their overall approach to promote a diet based on eating more fruits, vegetables, legumes, and whole grains, eating less added sugar and saturated fat, and using plant oils. Comparison between different food guides including the USDA's MyPyramid and the Harvard Healthy Eating Pyramid showed that nutrient intakes derived from the guides were similar despite the different foods suggested in each plan [31].

In addition to being a key source of energy, protein, micronutrients and phytochemicals to the diet, whole-grain cereals are an important source of different dietary fibres. Increased consumption of whole grains improves the overall quality of the diet and in particular is a good way to increase dietary fibre intake which in many countries is lower than recommendations. The fact that fibre consumption remains low, in parallel with low intake of whole grains in most countries, suggests that this approach has not been successful and new strategies are needed to improve this deficit [32]. As an example, the Danish dietary recommendation is based on modelling of dietary intake assuming that targets for fruit and vegetable consumption are achieved and that the additional dietary fibre should come from other food sources including wholegrain foods. Whole grain intake in Denmark has increased markedly by 72% from a population average of 32 g/day in 2000-2004 to 55g/day in 2011-2012 [33] following the successful Danish national campaign to promote whole grain intake. The proportion of Danes meeting the Danish target of 75 g/10MJ rose from 6 to 27% of the population demonstrating that a well-designed public health campaign in support of a specific dietary recommendation can be effective in promoting dietary change.

Within the scientific community there is broad consensus on the health benefits of consuming whole grains, but this has not translated into consistent health messages and dietary recommendations. The wide range of dietary recommendations found in this investigation, and the lack of recommendations in many countries should be addressed; where possible, countries without whole grain recommendations should be encouraged to incorporate them into dietary guidelines. In our opinion this is best achieved through the development of a science-based consensus or expert opinion on whole grain recommendations with a global reach. Such an expert opinion should consider the totality of available scientific evidence to address the following:

- Whether a global standard definition for whole grain and wholegrain food can be adopted;
- Whether a global whole grain intake recommendation is possible;
- Whether a whole grain recommendation should be generic, or whether a recommendation should be based on a specific grain type, e.g. wholegrain wheat or wholegrain rye;
- Whether a whole grain recommendation should be quantitative or generic, e.g. 'consume x grams of whole grain' or 'eat more whole grains';

The purpose of the developed recommendation would be to guide health policies and raise consumer awareness of whole grains in order to change peoples' diets to derive a greater proportion of dietary energy from cereal foods which provide dietary fibre and associated micronutrients and phytochemicals that are lost in the refining process. A greater harmonisation in approach would not only aid health professionals develop strategies to increase whole grain consumption, but would encourage and enable food manufacturers to develop healthy and affordable products containing whole grains.

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343 members of the HEALTHGRAIN Forum, a not-for-profit Association bounded by the Finnish
344 Associations Act No. 503 of 26 May 1989 pursuing a networking and scientific aim to
345 promote and develop grain and grain products.

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Table 1. Whole grain intake in different populations

Country	Gender (*n*)	Age group	Mean intake g/day (SD)	Median intake	Source [year data collected]
Norway	F (1,797)	48 (42-55)†	51 (36)	44 (0, 120)†	
Sweden	F (1,617)	50 (40-60)†	41 (32)	35 (0, 120)†	
	M (1,372)	60 (40-60)†	58 (50)	49 (0, 149)†	[20] [1995-2000]
Denmark	F (1,994)	56 (51-64)†	37 (32)	31 (0, 92)†	
	M (1,922)	56 (51-64)†	48 (42)	41 (0, 116)†	
France	Both (1,171)	3-17	4 (0.3)	0 (20.5)*	[34]
	Both (1,389)	>18	5 (0.3)	0 (26.4)*	[2010]
UK	F (729)	1.5-17	15.3 (15.0)	11 (4, 42)	[18]
	M (773)	1.5-17	20.1 (20.4)	15 (5, 29)	[2008-2011]
	F (880)	≥18	23.6 (22.8)	19 (6, 35)	
	M (691)	≥18	28.9 (31.1)	20 (3, 42)	
Germany	F (275)	6-12	22 (22.9)	14.7 (0, 57)‡	
	M (280)	6-12	27 (29.5)	17.9 (0, 66)‡	[35]
	F (165)	13-18	24 (28.7)	16.3 (0, 56)‡	[1997-2008]
	M (170)	13-18	33 (43.7)	19.2 (0, 84)‡	
Ireland	Both (594)	5-12	18.5 (18.2)	12.7 (68.5)#	[36]
	Both (441)	13-17	23.2 (29.5)	13.4 (97.9)#	[2003-2006]§
	Both (1,051)	18-90	36.3 (34.0)	29.0 (118.9)#	[37] [2008-2010]
USA	Both (3124)	2-18	16.2 (0.57)||		[38]
	Both (5918)	≥19	23.2 (0.85)||		[2009-2010]

† Median (5, 95 percentile)
* Median (95 percentile)
‡ Median (10, 90 percentile)
# 50th percentile (97.5 percentile)
§ 2003-2004 for age 5-12; 2005-2006 for age 13-17
|| Mean (SE)

Table 2. Countries surveyed and sources identified

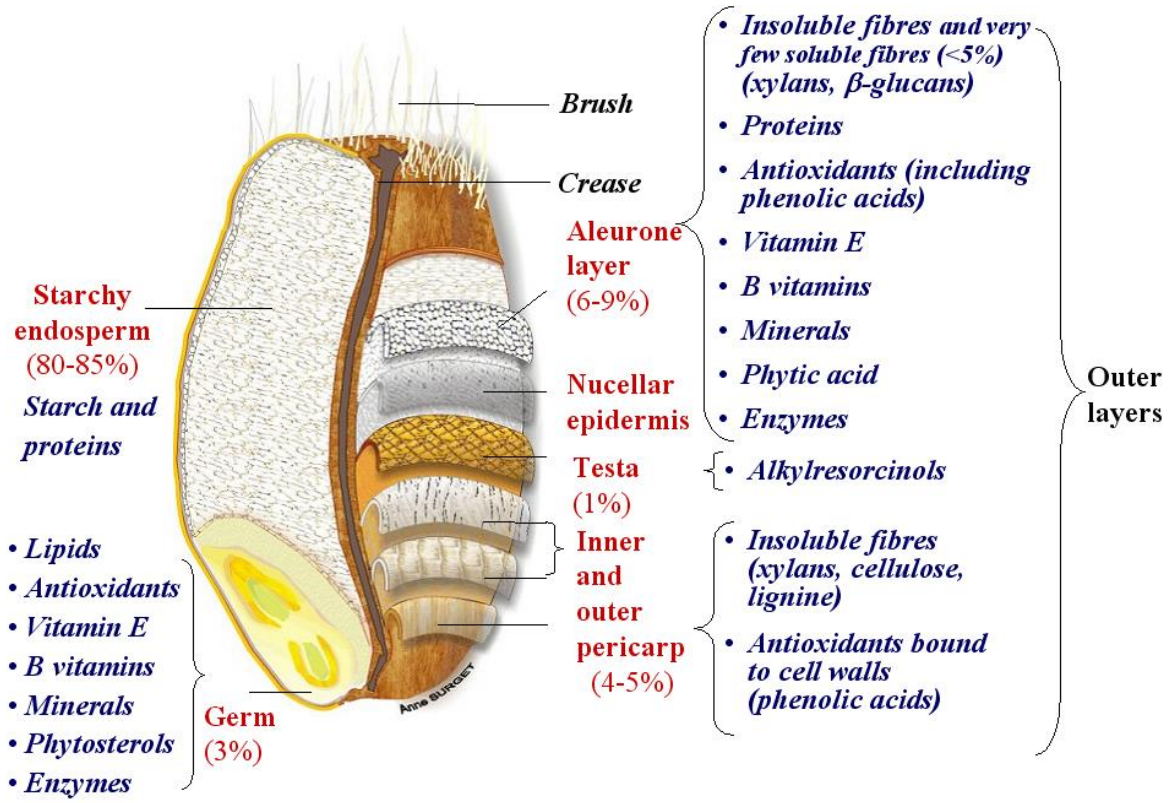
Region	Countries searched (n)	Organisations screened (n)		Recommendation			
		Government authority	NGO/charity/ professional body	Yes	No	Primary	Secondary
Australia & New Zealand	2	2	2	4	0	1	3
Asia	10	5	18	4	14	1	3
Europe	19	11	51	22	16	6	16
Africa & S. Africa	2	2	2	3	1	3	0
North America	2	2	7	9	0	5	4
Latin America	9	6	5	4	7	0	4
Middle East	9	9	3	2	2	1	1
WHO	n/a	0	1	1	0	1	0
EFSA	n/a	0	1	0	1	n/a	n/a
Total	53	37	90	49	41	18	31

Table 3. Examples of whole grain dietary recommendations.

Type	Example text	Country and organisation	Source*
Specific	4 portions per day, equal to minimum 75 g wholegrain/10 MJ	Danish Veterinary and Food Administration (2012). The Danish Food Based Dietary Guidelines	http://altomkost.dk/raad-og-anbefalinger/de-officielle-kostraad/vaelg-fuldkorn/
	Make one-half of your grains whole grains. Eat at least 3-oz equivalents (servings) of whole grains daily	US Department of Agriculture (2010) Dietary Guidelines for Americans 2010	http://health.gov/dietaryguidelines/dga2010/dietaryguidelines2010.pdf
Semi-specific	It is advised to consume at least a third of daily consumption of cereals from whole grain bread and foods that contain whole grains.	Oman, Ministry of Health, Department of Nutrition	http://www.fao.org/ag/humannutrition/19541-0497c1ce489201fde6e93d72cc6b91a9d.pdf
	Eat sufficient amounts of grains, especially whole grains. At least one serving of rice and alternatives should come from wholegrain food as they contain both the bran and the germ.	Singapore, Health Promotion Board	http://www.hpb.gov.sg/HOPPortal/faces/oracle/webcenter/portalapp/pages/HealthTopics/ArticlePage/ArticlePage.jspx?dDocName=2758&topicName=Food%20for%20Health&_afrLoop=91335222517341954&_afrWindowMode=0&_afrWindowId=null#!%40%40%3F_afrWindowId%3Dnull%26_afrLoop%3D91335222517341954%26dDocName%3D2758%26_afrWindowMode%3D0%26topicName%3DFood%2Bfor%2BHealth%26_adf.ctrl-state%3D9xv5nrxwh_4
	Ensure at least half of daily cereal intake includes whole grains	Malaysia, Ministry of Health Malaysia	http://www.moh.gov.my/images/gallery/Garispanduan/diet/KM4.pdf
Non-specific	Starchy foods such as potatoes, bread, cereals, rice and pasta should make up about a third of the food you eat. Where you can, choose wholegrain varieties, or eat potatoes with their skins on for more fibre.	UK, NHS Choices	http://www.nhs.uk/Livewell/Goodfood/Pages/starchy-foods.aspx

***All websites were accessed November 2015**

Figure 1. Anatomical structure of a whole wheat grain [39; 40].



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Supplementary Table: Countries and organisations with whole grain recommendations

Country	Issuing Organisation	Year of recommendation	Whole grain recommendation	Rationale	Recommendation URL Reference*
Australia	Grains and Legumes Nutrition Council (former Go Grains)	2014	Whole Grain Daily Target Intake (DTI) is 48 grams per day for adults and children nine years and older.	Whole grain foods are linked with a reduction in risk of total mortality cardiovascular disease, diabetes, stroke and some cancers.	http://www.glnc.org.au/codeofpractice/whole-grain-daily-target-intake-statement/
Australia	Australian Heart Foundation	2006	As part of your total fibre intake you should consume at least 6 grams of wholegrain fibre per day.	Because these foods have undergone little or no processing, they provide a range of essential nutrients such as B vitamins, magnesium and antioxidants. Whole grain foods, apart from their dietary fibre content, have been shown in studies to help protect against heart disease although exactly how is not known.	http://www.heartfoundation.org.au/SiteCollectionDocuments/Dietary-fibre-gycaemic-index-general-QA.pdf
Australia	National Health and Medical Research Council of Australia	2003	Eat plenty of cereals (including breads, rice, pasta and noodles), preferably wholegrain	All recent reviews have supported the beneficial effects of cereal fibre and whole grains in relation to decreased risk of coronary heart disease and some cancers	http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/n33.pdf

Austria	Health Ministry	n/a**	Eat 4 servings of carbohydrates per day. Prefer whole grain products.	n/a	http://bmg.gv.at/home/Schwerpunkte/Ernaehrung/Empfehlungen/Die_Ernährungspyramide_im_Detail_-_7_Stufen_zur_Gesundheit
Belgium	Superior Health Council	2009	Intake of at least 30 gram of fibre for adult. The intake of carbohydrates should preferably been done by whole grain products, legumes, vegetables and fruit.	An intake of 30 gram of fibre or more is associated with improved intestinal function and to decrease the risk for cardiovascular disease, obesity, certain types of cancer, and to decrease infections and inflammatory pathologies.	http://v2p.health.fgov.be/internet2Prd/groups/public/@public/@shc/documents/ie2divers/18014679.pdf
Brazil	Health Ministry	2014	Less processed versions of these foods, such as brown rice and whole-wheat flower are preferable	Higher amounts of micronutrients and fibre.	http://www.foodpolitics.com/wp-content/uploads/Brazilian-Dietary-Guidelines-2014.pdf
Canada	Canada's Food Guide	2007	Make at least half of your grain products whole grain each day. Eat a variety of whole grains such as barley, brown rice, oats, quinoa and wild rice. Enjoy whole grain breads, oatmeal or whole wheat pasta." At least three servings of whole grains are recommended for all Canadians age 9 years and up.	Fibre rich foods can help you feel full and satisfied. A diet rich in whole grains may also help reduce the risk of heart disease.	http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/choose-choix/grain-cereal/index-eng.php

China	Chinese Nutrition Society	2007	Eat a mix of refined and coarse grains and to consume at least 50 g of coarse grain per day	Consuming coarse grains have the benefit of preventing obesity, diabetes and other chronic diseases. Having 85g of whole grains per day can reduce the risk of certain chronic diseases and help manage body weight	http://dg.en.cnsoc.org/newsList_1501_1.htm
Colombia	Health Ministry	1999	There is a need to promote consumption of wholegrain instead of refined grain	n/a	http://www.icbf.gov.co/portal/page/portal/PortalICBF/Bienestar/Nutricion/EducacionAlimentaria/BASESTECNICASGUIAALIMENTARIAPOBLACIONMAYORDE2A%C3%91OS.pdf
Czech republic	Czech Society for Health and Nutrition	2009	Eat at least 30 g of fibre per day, eat 3-6 portions of cereals, rice, pasta and pastry, preferably whole grain products,	Beneficial effects related to prevalence of colon cancer.	www.vyzivaspol.cz
Denmark	Report of the National Food Institute	n/a	At least 75g per day	Wholegrain products could reduce risk factors for heart disease, mainly documented for the effect of oats on blood lipids and lipoproteins. The association is consistent, relatively strong (20-30% risk reduction), independent of other lifestyle factors, and biologically plausible. The focus has mainly been on wholegrain's contribution of dietary fibres, magnesium and potassium, and antioxidants (especially	http://www.google.ch/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=1&cad=rja&uact=8&ved=0CB4QFjAAahUKEwjThuDL--7GAhVLkiwKHbQMBO0&url=http%3A%2F%2Fwww.food.dtu.dk%2F~%2Fmedia%2FInstitutter%2FFoedevareinstituttet%2FPublikationer%2FPub-2013%2FRapport_Fuldkornsindtag_11-12_UK.ashx&ei=5qqvVdP7D8uksgG0mZDoDg&usg=AFQjCNE0nDJK8AF434-xUxk_CrTUvxkrHg&bvm=bv.98197061,d.bGg

				vitamin E), which have documented effects on insulin sensitivity, blood lipids and lipoproteins, and blood pressure. Having said this, none of the above single components can explain the overall association.	
Denmark	Ministry of Food, Agriculture and Fishing	2010	At least 75g per day	Whole grains contain vitamins, minerals and other health-promoting substances, which are critical to avoid diseases like diabetes, heart disease and certain cancers. Whole grains consist of a complex package of ingredients, and it is likely that the combination of all ingredients ("whole package") that are important for disease risk and not specific to individual substances.	http://www.altomkost.dk/fakta/fuldkorn/forside.htm
Ecuador	Instituto Ecuatoriano de Normalización	2008	25 g of dietary fibre per day, eat 3 portion per day of whole grain products (rice, pasta, cookies, bread)	Low intake of dietary fibre causes constipation and high cholesterol levels	personal communication

Finland	National Nutrition Council	2014	Eat whole meal bread	n/a	http://www.ravitsemusneuvottelukunta.fi/portal/fi/vinkkeja+viisaisiin+valintoihin/
France	Programme National Nutrition Sante	2011	Eat bread and starchy foods at every meal. Bread should be preferably whole grain or semi-whole grain	Whole grains are rich in fibre	http://www.mangerbouger.fr/
Germany	German Nutrition Society	2009	Minimum 30 gram fibre per day, preferably from whole grain	High consumption of fibre decreases the risk for various nutrition-related diseases	https://www.dge.de/ernaehrungspraxis/vollwertige-ernaehrung/10-regeln-der-dge/
Greece	Ministry of Health	1999	Prefer whole grain bread and pasta. 8 micro-portions of cereals, mostly whole grain products. A micro-portion is 25g of bread, 1/2 cup rice and 50-60g pasta.	Provide a significant amount of fibre	http://www.mednet.gr/archives/1999-5/pdf/516.pdf
Hungary	Ministry of Health - nutrition policy guidelines with recommendations from the National Institute for Health	2010	5-9 unit/day of cereals (mostly whole grains)	Prevention of cardiovascular system disease, reduction of the too high blood lipid levels	http://www.oeti.hu; http://www.euro.who.int/__data/assets/pdf_file/0017/150083/E79832.pdf

Ireland	Diabetes Federation of Ireland	n/a	Reach for whole grain or high fibre options	Help you feel fuller for longer, and because they are more slowly digested, will help to stabilize your blood glucose levels. They will also provide fibre to help your digestive health	http://www.diabetes.ie/living-with-diabetes/living-with-type-2/food-diabetes/food-groups/
Ireland	Department of Health	2012	Have at least half your servings as wholegrain breads and high fibre breakfast cereals. Try using brown rice and wholewheat pasta	These provide a slow release of energy. Wholegrain choices contain fibre to help your digestive system.	http://health.gov.ie/healthy-ireland/health-promotion-and-improvement/
Israel	Ministry of Health	2015	Preference of fibre-rich foods. For example – whole-grain cereals, legumes, vegetables and fruit	Rich in fibre.	http://www.health.gov.il/English/Topics/FoodAndNutrition/Nutrition/Adequate_nutrition/Pages/default.aspx
Malaysia	Ministry of Health Malaysia	2010	Consume at least four servings of cereal foods daily. Choose at least half of your grain products from whole grain. Choose cereal products that are high in fibre, low in fat, sugar and salt.	Amount of vitamins, minerals and other protective substances, but the most obvious difference is the content of dietary fibre.	http://www.moh.gov.my/images/gallery/Garispanduan/diet/KM4.pdf
Mexico	Mexican Health Ministry	2013	Consumption of cereals should be recommended, preferably whole grains or their derivates and starchy roots. Their fibre	Improve Mexican diet.	http://www.dof.gob.mx/nota_detalle.php?codigo=5285372&fecha=22/01/2013

			and energy content should be highlighted		
Netherlands	Voedingscentrum	2015	Eat at least 90 g daily bread, whole meal bread or other whole grains. Replace refined grain products with whole grain	whole grains reduce disease risk	http://www.voedingscentrum.nl/Assets/Uploads/voedingscentrum/Documents/Professionals/Voedselvoorlichting/01_Richtlijnen%20voedselkeuze%20Voedingscentrum.pdf
New Zealand	Ministry of Health	2012	Eat plenty of breads and cereals, preferably wholegrain	They contain the most fibre, vitamins and minerals and help prevent constipation.	http://www.health.govt.nz/our-work/preventative-health-wellness/nutrition/food-and-nutrition-guidelines/nz-food-and-nutrition-guideline-statements-healthy-adults
Norway	Directorate of Health Norway	2005	Choose whole grain bread and cereals	Considerably higher content of dietary fibre and necessary nutrients than refined grain products such as white bread and sifted flour.	http://www.helsedirektoratet.no/ernaering/kostholdsrad/
Oman	Department of Nutrition Ministry of Health Oman	2009	Consume at least a third of daily consumption of cereals from whole grain bread and foods that contain whole grains . Therefore for an average diet of 2000 calories 2-3 servings of whole grains daily is advised.	Positively associated with insulin sensitivity, better weight control management, prevention of heart diseases and cancer. Some studies suggest a preventive role of whole grains against cancer. They are also a major source of dietary fibre that is known to promote satiety; regulate bowel movement and reduce	http://www.fao.org/ag/humannutrition/19541-0497c1ce489201fde6e93d72cc6b91a9d.pdf

				the risk of obesity; cancer and cardiovascular diseases. In addition whole grains are a good source of B vitamins and minerals and folate.	
Poland	Polish National Food and Nutrition Institute	2010	Cereal products should be your principal source of calories	n/a	http://www.fao.org/3/a-as837o.pdf
Singapore	Health Promotion Board	2003	Eat sufficient amount of grains, especially whole grains. At least one serving of rice and alternatives should come from wholegrain food	Wholegrain foods contain both the bran (which is high in B-vitamins) and germ (which is rich in Vitamin E & phytochemicals) and hence contain more nutrients and fibre than refined grains. People who have a diet rich in whole-grains have a lower risk of cardiovascular diseases, Type 2 Diabetes, colorectal and esophageal cancers and may assist in weight loss.	http://www.hpb.gov.sg/foodforhealth/article.aspx?id=2758
South Africa	Heart and Stroke foundation South Africa	2014	Eat plenty of the good stuff every day like vegetables and fruit, lentils and beans, low-fat dairy, wholegrain starches and lean protein foods.	These foods can help you feel fuller for longer and lower your risk of developing obesity, heart disease and cancer. Good examples are brown or whole wheat bread,	http://www.heartfoundation.co.za/gethealthy/eatwell_4.htm

				coarse maize (mealie) meal, oats and brown rice.	
South Africa	The Cancer Association of South Africa	2011	Make starchy foods that are high in roughage and whole-grains the basis of most meals. Eat more fibre, e.g. fruit and vegetables with skins included and whole grain foods such as Bokomo Weet-Bix and Bokomo Oats (both CANSA Smart Choices) mealie pap, brown rice and sorghum	n/a	http://www.cansa.org.za/eat-drink-smart/
South Africa	Department of Health	2013	South Africans should eat starchy foods in the form of minimally processed or whole grains, legumes and root vegetables, rather than as refined starches and sugars	Unrefined starchy foods let us 'feel full' longer than refined grains do. They are rich in fibre and support healthy bowel functioning. They also help to lower the risk of developing chronic diseases such as overweight and cardiovascular diseases	http://sajcn.co.za/index.php/SAJCN/article/view/743
Sweden	National Food Administration	2005	70 grams of whole grains per day for women and about 90 grams for men.	People who eat lots of whole grains are at lower risk of cardiovascular disease, diabetes, obesity and possibly cancer.	http://www.livsmedelsverket.se/en/

Sweden	Nordic Nutrition Recommendations	2012	The dietary pattern should include natural fibre-rich foods such as vegetables (e.g. dark-green leaves, fresh peas and beans, cabbage, onions, root vegetables, and fruiting vegetables), pulses, fruits, berries, nuts, seeds, and whole grains as well as fish and seafood, vegetable oils, vegetable oil-based fat spreads, and low-fat dairy products. Intake of dietary fibre should be at least 25–35 g/d, i.e. approximately 3 g/MJ. Wholegrain cereals, whole fruit, vegetables, pulses, and nuts should be the major sources.	fibre rich foods are associated with health benefits	http://norden.diva-portal.org/smash/get/diva2:704251/FULLTEXT01.pdf
Switzerland	Swiss Society for Nutrition	2014	Grains, Potatoes & Pulses: 3 portions per day. Grains should preferably be wholegrain. Lentils/chick peas or 180 – 300 g of potatoes or 45 – 75 g of pasta/rice/flakes/corn/other grains [raw weight]), including at least two	n/a	http://www.sge-ssn.ch/media/sge_pyramid_basic_E_2014.pdf

			portions of whole grain products.		
Thailand	Ministry of Public Health	1998	Consume more of unpolished rice or home pounded rice	Unpolished rice or home pounded rice is more nutritious than highly mill rice (polished rice) because it contains substantial nutrients such as protein, fat, dietary fibre, minerals and vitamins	http://www.fao.org/3/a-as887e.pdf
UK	British Heart Foundation		Whole grain bread is usually considered to be more healthy and to contain more vitamins and minerals than white bread	Contain more vitamins and minerals	http://diet.com/g/british-heart-foundation-diet
UK	Cancer Research UK	2015	Choose whole grain varieties of starchy foods wherever possible	Contains fibre	http://www.cancerresearchuk.org/about-cancer/causes-of-cancer/diet-and-cancer/how-to-enjoy-a-healthy-diet
UK	Department of Health	2015	choosing whole grain varieties when possible	Fibre can help to keep our bowels healthy, and can help us to feel full, which means we are less likely to eat too much. This makes wholegrain starchy foods a particularly good choice if you are trying to lose weight.	http://www.nhs.uk/Livewell/Goodfood/Pages/starchy-foods.aspx

UK	Heart UK	n/a	Choosing more whole grains	General cholesterol lowering	http://heartuk.org.uk/cholesterol-and-diet/about-the-uclp/the-three-uclp-steps/step-2-building-strong-foundations/choosing-more-whole-grains
USA	USDA/FDA (Dietary Guidelines for Americans)	2010	Consume at least half of all grains as whole grains. Increase whole grain intake by replacing refined grains with whole grains	People who eat whole grains as part of a healthy diet have a reduced risk of some chronic diseases. Grains provide many nutrients that are vital for the health and maintenance of our bodies.	http://www.health.gov/dietaryguidelines/dga2010/dietaryguidelines2010.pdf
USA	Academy of Nutrition and Dietetics	2014	Increase whole grains by choosing whole grain breads and cereals, brown rice and whole wheat pasta. Make at least half your grain servings whole grains	n/a	http://www.eatrightpro.org/~/media/eatrightpro%20files/career/career%20development/flyers%20and%20handouts/ernt_everyday_eating_for_a_healthier_you.ashx
USA	American Heart Association	2014	Eat a dietary pattern that emphasizes: fruits, vegetables, whole grains, low-fat dairy products, poultry, fish and nuts, while limiting red meat and sugary foods and beverages.	Whole grains are generally good sources of dietary fibre; most refined (processed) grains contain little fibre. Dietary fibre from whole grains, as part of an overall healthy diet, helps reduce blood cholesterol levels and may lower risk of heart disease. Grains are also important sources of many nutrients including B vitamins, Iron, magnesium and selenium.	http://www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/HealthyEating/The-American-Heart-Associations-Diet-and-Lifestyle-Recommendations_UCM_305855_Article.jsp

USA	American Diabetes Association	2008	Consume at least half of all grains as whole grains	Reduced risk of diabetes with increased intake of whole grains and dietary fibre.	http://care.diabetesjournals.org/content/31/Supplement_1/S61.full
USA	American Cancer Society	2015	Choose whole grains instead of refined grain products	Linked with lower colorectal cancer risk.	http://www.cancer.org/acs/groups/cid/documents/webcontent/002577-pdf.pdf
USA	3x societies: American Association of Clinical Endocrinologists/the American College of Endocrinology and the Obesity Society***	2013	Patients should consume 6 to 8 servings of carbohydrates (one serving is 15 grams of carbohydrate) per day with at least half (3 to 4 servings) being from high-fibre, whole grain products	Whole grains in place of refined grains, will add fibre and micronutrients to meals and help lower blood pressure.	https://www.aace.com/files/clinical-practice-guidelines.pdf
	WHO	2003	Supporting the availability and selection of nutrient-dense foods (fruits, vegetables, legumes, whole grains, lean meats and low-fat dairy products and low-fat dairy products).	nutrient dense foods, high in fibre	http://www.who.int/dietphysicalactivity/publications/trs916/en/

*Web sites accessed July-November 2015

**n/a Information not available at source

***3 societies with one joint recommendation

Supplementary Table: Countries and organisations screened

Country	Organisation			Comments		
		Health Ministry	NGO/others	With recommendation	No recommendation	Language not available to the authors
Argentina	Health Ministry	1			1	
Australia	Go Grains (now GLNC)		1	1		
Australia	Australian Heart Foundation		1	1		
Australia	National Health and Medical Research Council	1		1		
Austria	Health Ministry	1		1		
Bahrain	Health Ministry	1				1
Belgium	Association Belge du Diabète		1		1	
Belgium	Ligue Cardiologique Belge		1		1	
Belgium	Fondation contre le Cancer		1		1	
Belgium	Superior Health Council	1		1		
Bolivia	Health Ministry	1			1	
Brazil	Sociedade Brasileira de Cardiologia		1		1	
Brazil	Health Ministry	1		1		
Bulgaria	Дружество на кардиолозите в България		1			1
Bulgaria	Bulgarian Diabetes Association		1			1
Canada	Canada's Food Guide	1		1		
Chile	Sociedad Chilena de Cardiología		1		1	
China	Chinese Diabetes Society		1			1

China	Chinese Society of Cardiology		1			1
China	Chinese Nutrition Society		1	1		
Colombia	Health Ministry	1		1		
Czech republic	Czech Society for Health and Nutrition		1	1		
Denmark	Diabetesforeningen		1			1
Denmark	Hjerteforeningens		1			1
Denmark	Danish Cancer Society		1			1
Denmark	Report of the National Food Institute		1	1		
Denmark	Ministry of Food, Agriculture and Fishing	1		1		
Ecuador	La Sociedad Ecuatoriana de Cardiología		1		1	
Ecuador	Instituto Ecuatoriano de Normalización		1	1		
Finland	National Nutrition Council		1	1		
Finland	Finnish Diabetes Association		1			1
Finland	Cancer Society of Finland		1			1
Finland	Finnish Heart Association		1			1
France	Programme National Nutrition Sante	1		1		
Germany	Diabetes-Union		1		1	
Germany	Deutsche Herzstiftung		1		1	
Germany	Deutsche Krebshilfe		1		1	
Germany	German Nutrition Society		1	1		
Ghana	Ministry of Agriculture	1			1	
Greece	Hellenic Heart Foundation		1			1

Greece	Greek Cancer Society		1			1
Greece	Ministry of Health	1		1		
Hungary	Hungarian Diabetes Association		1			1
Hungary	Hungarian National Heart Foundation		1			1
Hungary	Ministry of Health	1		1		
India	Diabetes India		1		1	
India	National Heart Institute		1		1	
India	India Cancer Society		1		1	
Indonesia	Indonesia Heart Foundation		1		1	
Iran	Health Ministry	1			1	
Iraq	Health Ministry	1			1	
Ireland	Diabetes Federation of Ireland		1	1		
Ireland	Irish Heart Foundation		1		1	
Ireland	Irish Cancer Society		1		1	
Ireland	Department of Health	1		1		
Ireland	Food Safety Authority of Ireland		1		1	
Israel	Israel Diabetes Association		1			1
Israel	Israel Heart Society		1			1
Israel	Israel Cancer Association		1			1
Israel	Ministry of Health	1		1		
Japan	Japan Diabetes Society		1			1
Japan	Japan Heart Foundation		1			1
Japan	Japan Cancer Society		1			1
Kuwait	Health Ministry	1			1	
Lebanon	Health Ministry	1			1	
Malaysia	Malaysian Diabetes Association		1		1	

Malaysia	The Heart Foundation of Malaysia		1		1	
Malaysia	National Cancer Council Malaysia		1		1	
Malaysia	Ministry of Health Malaysia	1		1		
Mexico	Mexican Health Ministry	1		1		
Netherlands	Diabetesvereniging		1			1
Netherlands	Hartstichting		1			1
Netherlands	ankerbestrijding		1			1
Netherlands	Netherlands Nutrition Centre recommends		1			1
Netherlands	Voedingscentrum		1	1		
New Zealand	Ministry of Health	1		1		
Norway	Norwegian Diabetes Association		1			1
Norway	Nasjonalforeningens		1			1
Norway	Norwegian Cancer Society		1			1
Norway	Directorate of Health Norway	1		1		
Oman	Department of Nutrition Ministry of Health	1		1		
Palestine	Health Ministry	1				1
Peru	Sociedad Peruana de Cardiología		1		1	
Philippines	DIABETES PHILIPPINES		1		1	
Philippines	Philippine Heart Association		1		1	
Poland	Polish Cardiac Society		1			1
Poland	Polska Unia Onkologii		1			1
Poland	Polish National Food and Nutrition Institute		1	1		
Portugal	Portuguese Diabetes Association		1		1	

Portugal	Fundação Portuguesa de Cardiologia		1		1	
Portugal	Portuguese Cancer League		1		1	
Qatar	Health Ministry	1				1
Singapore	Diabetic Society of Singapore		1		1	
Singapore	Singapore Heart Foundation		1		1	
Singapore	Singapore Cancer Society		1		1	
Singapore	Health Promotion Board	1		1		
South Africa	Heart and Stroke foundation South Africa		1	1		
South Africa	The Cancer Association of South Africa		1	1		
South Africa	Department of Health	1		1		
Sweden	Svenska Diabetesförbundet		1			1
Sweden	Swedish Heart Lung Foundation		1			1
Sweden	Swedish Cancer Society		1			1
Sweden	National Food Administration	1		1		
Sweden	Nordic Nutrition Recommendations		1	1		
Switzerland	Schweizerische Diabetes-Gesellschaft		1		1	
Switzerland	Swiss Cancer League		1		1	
Switzerland	Swiss Society for Nutrition		1	1		
Syria	Health Ministry	1				1
Thailand	Ministry of Public Health	1		1		
UK	Diabetes UK		1		1	
UK	British heart foundation		1	1		
UK	Cancer research UK		1	1		

UK	Department of Health	1		1		
UK	Heart UK		1	1		
Ukraine	Health Ministry	1			1	
USA	USDA/FDA	1		1		
USA	Academy of Nutrition and Dietetics		1	1		
USA	American Heart Association		1	1		
USA	American Diabetes Association		1	1		
USA	American Cancer Society		1	1		
USA	3x societies: American Association of Clinical Endocrinologists/the American College of Endocrinology and the Obesity Society		3	3		
Venezuela	Health Ministry	1			1	
Yemen	Health Ministry	1				1
	WHO		1	1		
	EFSA		1		1	